



USAID
FROM THE AMERICAN PEOPLE

MORROCO ECONOMIC COMPETITIVENESS

INFORMATION MANAGEMENT SYSTEM STUDY TOUR FOR
MOROCCAN RIVER BASIN AGENCY AND WATER DISTRICT
OFFICIALS



DATE : JUNE 2013

MEC DOCUMENT I 45

This publication was produced for review by the United States Agency for International Development (USAID). It was prepared by DAI.

MORROCO ECONOMIC COMPETITIVENESS

INFORMATION MANAGEMENT SYSTEM STUDY TOUR
FOR MOROCCAN RIVER BASIN AGENCY AND WATER
DISTRICT OFFICIALS

Submitted to USAID/Morocco, Economic Growth Office - Assistance Objective 3: Reduced barriers to trade and investment

By DAI

Contract Number: EEM-I-00-07-00009-00: Task Order Number: EEM-I-07-07-00009

The authors' views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

Morocco Economic Competitiveness Program

8, rue du Rif

Souissi

10 000 Rabat

Morocco

Tel: (212) 05 37 63 05 59

Fax: (212) 05 37 63 05 61

andrew_watson@dai.com

<http://www.programmemec.ma>

TABLE OF CONTENTS

Summary	1
1. Background and Objectives.....	3
2. Participants.....	5
3. Program Overview.....	7
4. Program Details	9
4.1 US Army Corps of Engineers, Institute for Water Research (USACE – IWR), Alexandria, Virginia	9
4.2 US Geologic Survey (USGS), International Water Resources Branch, Reston, Virginia.....	9
4.3 US Bureau of Reclamation (USBR), International Affairs, Washington, DC.....	10
4.4 NOAA/National Weather Service (NWS), Silver Spring, Maryland.....	10
4.5 NOAA/National Centers for Environmental Prediction (NCEP), Greenbelt, Maryland	11
4.6 Development Alternatives Inc (DAI), Bethesda, Maryland	11
4.7 NASA Goddard Space Flight Center (GSFC), Greenbelt, Maryland	12
4.8 The World Bank, Washington, DC	12
4.9 Stanford University, Woods Institute for the Environment, Natural Capital Project	12
4.10 Google, Mountain View California	13
4.11 US Army Corps of Engineers - Hydrologic Engineering Center (HEC), Davis California....	13
4.12 California Department of Water Resources (DWR), Joint Operations Office, Sacramento 14	
4.13 California State Water Resource Board, Sacramento.....	14
4.14 Byron Bethany Irrigation District, Central Valley, California	15
4.15 Gallo Family Vineyards.....	15
4.16 NASA-Ames Research Center, Earth Science Division	16
5. Conclusions.....	17

SUMMARY

The Moroccan Study Tour delegation included 16 officials from the Moroccan River Basin Agencies (ABHs) and Water Districts (ORMVAs) plus three MEC project experts. The Study Tour was conducted in Washington, DC and California during April, 2013.

The Study Tour supports MEC's *Intermediate Result 2: Water Use Sustainably for Agricultural Growth*. ABH and ORMVA officials were exposed to U.S. agencies involved with research, operations and international programs relevant to Morocco with a focus on successful Information Management Systems. Agencies visited in the U.S. included federal, state water management officials, water districts managing for multiple uses including irrigation, municipal, industrial and environmental needs, irrigation companies and private sector corporations.

The Moroccan delegation was exposed to a range of highly relevant water resources issues facing the U.S. and highly relevant to Morocco. Meetings, presentations, dialogue and exchange were conducted with key federal agencies responsible for water resources management, policy and governance; state operations and regulatory agencies; developers of models and data management tools; private sector innovators in science and technology; and field water managers serving complex and often competing interests including municipal, irrigation, and environmental interests. The meetings and presentations stimulated discussions about the very similar issues in Morocco and, particularly, how data management, modeling tools, management approaches, and policies could be improved. Professional contacts were made at each U.S. and Moroccan agency, with much anticipation for future collaboration.

I. BACKGROUND AND OBJECTIVES

The Study Tour was conducted in Washington, DC and California during the period 31 March through 12 April, 2013. The Moroccan delegation included 16 officials from the Moroccan River Basin Agencies (ABHs) and Water Districts (ORMVAs) plus three experts from Riverside Technology, inc.

The U.S. organizations, technical program, and agenda were arranged by Riverside Technology, inc. USAID/Morocco and the MEC project team prepared visas, security clearances, etc. and DAI/Bethesda arranged the logistics and travel details.

The Study Tour was relevant to achieving the overall goal of MEC's *Intermediate Result 2: Water Use Sustainably for Agricultural Growth*, which is implementing reforms leading to better use and efficiency of water resources. The objective of the Study Tour was to expose ABH and ORMVA officials to U.S. agencies involved with research, operations and international programs relevant to Morocco with a focus on successful Information Management Systems that are used in applications similar to the Morocco context. The meetings and visitations simulated a great deal of dialogue, professional networking and a basis for future collaboration. Agencies visited in the U.S. included federal, state water management officials, water districts managing for multiple uses including irrigation, municipal, industrial and environmental needs, irrigation companies and private sector corporations.

The ABHs of the Moulouya River and the Oum Er Rbia River are the main public agencies in charge of water resources planning and management at the river basin level in Morocco. Their main tasks include:

- Water resources quantity and quality monitoring, including both surface water and groundwater resources;
- Periodic assessment of water resources at the river basin level;
- Water resources planning and allocation to various sectors: agriculture, drinking and industrial water supply, etc.;
- Enforcement of the water law provisions to ensure appropriate water resources management;
- Setting up a database on water resources at the river basin level.

The two ORMVAs of Moulouya and Doukkala are the main public agencies in charge of irrigation management. Their tasks include the following main functions:

- Allocation and distribution of water among farmers for irrigation;
- Operation and maintenance of irrigation infrastructure at the level of the irrigation scheme;
- Monitoring of water consumption in irrigation;
- Collecting irrigation fees from farmers;
- Monitoring of cultivated crops;
- Setting up database at the level of the irrigation scheme

The Moroccan visitors from the RBAs and ORMVAs were interested in discussing and learning about all aspects of water resources and river basin management as practiced in the US, including:

- Decision Support Systems for Water Resources and River Basin Management
- Information Management Systems (IMS) and Databases

- Irrigation Management, Scheduling, Monitoring and Efficiency
- Reservoir Operations for Water Supply, Hydropower, and Flood Control
- Geographic Information Systems, Geospatial Modeling and Spatial Data Visualization
- River and Flood Forecasting including Real Time Data, Hydrologic and Meteorologic Modeling and Forecast Product Dissemination
- Satellite Applications and Remote Sensing for Monitoring Earth Processes and Water Resources
- Trans-national and Trans-basin Diversions, Monitoring and Management
- Water Rights, Water Allocation and Water Law
- Groundwater Monitoring and Management
- Water Quality Modeling
- Research and Applications for Water Management
- Climate Change, Adaptation and Water Management
- International Center for Modeling and Climate Change Analysis

2. PARTICIPANTS

Study Tour participants were nominated from their respective agencies. MEC project personnel conducted interviews with each prospective participant to determine their commitment and potential contribution to the group in achieving the goals and objective. Table I provides a list of the participants and their agency affiliation.

3. PROGRAM OVERVIEW

The Study Tour was conducted in the Washington, DC area and in San Francisco and Sacramento, California regions and included visits to the following organizations:

- US Army Corps of Engineers – Institute for Water Research (USACE – IWR)
- US Geologic Survey (USGS)
- US Bureau of Reclamation (USBR)
- NOAA/National Weather Service (NWS)
- NOAA/National Centers for Environmental Prediction (NCEP)
- Development Alternatives Inc (DAI)
- Riverside Technology, inc.
- NASA – Goddard Space Flight Center (GSFC)
- The World Bank
- Stanford University – Natural Capital Project
- Google
- US Army Corps of Engineers - Hydrologic Engineering Center (HEC)
- California Department of Water Resources (DWR)
- California State Water Resource Board
- California Nevada River Forecast Center (CNRFC)
- Gallo Family Vineyards
- NASA-Ames Research Center
- Byron Bethany Irrigation District

Table 1: Study Tour Participants

First Name	Last Name	Agency	Department	Job Position
Ehssan	El Meknassi-Youssoufi	Ministry of Agriculture	Planning and Monitoring of Water Resources	Head of Division
Abdelaziz	Zerouali	Ministry of Water	Department of Water	Senior Engineer
Abdeslam	Ziyad	Ministry of Water	Water Planning and Management	Head of Division
Rachid	Boutafoust	Office Regional de Mise en Valeur Agricole de Doukkala	Irrigation and Drainage Division	GIS Cell Head
Latifa	Gana	Office Regional de Mise en Valeur Agricole de Doukkala	Irrigation and Drainage Division	Irrigation Engineer
El Mostafa	Majjouj	Office Regional de Mise en Valeur Agricole de Doukkala	Irrigation Programs Bureau	Head of Division
Hamid	Chebabi	Office Regional de Mise en Valeur Agricole de Moulouya	Agriculture Production	Head of Division
Abdellatif	El Ghali	Office Regional de Mise en Valeur Agricole de Moulouya	Irrigation Network Management Service	Head of Division
Abdessamad	El Kassimi	Office Regional de Mise en Valeur Agricole de Moulouya	Bureau of Irrigation	Chief Engineer of Irrigation Bureau
Abderraouf	Bencheikhe	River Basin Agency of Moulouya	GIS and Information	GIS Technician
Mohammed	Chanigui	River Basin Agency of Moulouya	Hydrogeology	Engineer, Head of Hydrogeology Division
Mohammed	Chtioui	River Basin Agency of Moulouya	Director	Director of the Agency
Mohamed	Abbane	River Basin Agency of Oum Er Rbia	Water Resources Monitoring	Principal Engineer
Brahim	Aghazzaf	River Basin Agency of Oum Er Rbia	Hydrogeology Department	Senior Engineer
Mustapha	Bayoumi	River Basin Agency of Oum Er Rbia	Infrastructure Department	Chief Engineer-Head of Infrastructure Division
Bouchaib	Hakkani	River Basin Agency of Oum Er Rbia	Hydrology Department	Senior Engineer
Driss	Ennaanay	Riverside Technology	Operations	Program Leader
Timothy	Martin	Riverside Technology	Corporate	Vice President
Mostafa	El Haiba	USAID-MEC	MEC	Water Resources Management Specialist

4. PROGRAM DETAILS

4.1 US ARMY CORPS OF ENGINEERS, INSTITUTE FOR WATER RESEARCH (USACE – IWR), ALEXANDRIA, VIRGINIA

Attending: Robert Brumbaugh, Jorge Alcala, Andrew Bruzewicz, Eugene Stakhiv, Jerome (Jerry) Delli Priscoli, Kristin Gilroy, Gillermo Mendoza, Will Logan, Hal Cardwell, Bob Pietrowsky, and others

Comprehensive presentations were delivered by USACE officials in this all-day meeting including Institute for Water Resources (IWR), Institute for Water Resources & International Center for Integrated Water Resources Management, overviews of Hydrologic Engineering Center and Corps Water Management System (CWMS), the IWR Risk Management Center and the Civil-Military Emergency Preparedness (CMEP) Program Conflict Resolution and Public Participation Center of Expertise (CEIWR – CPC).

A number of USACE studies and planning initiatives require assessment of climate change and adaptation programs using approaches outlined by Alliance for Global Water Adaptation and others. A series of tools are being used for downscaling climate change projection data and water management applications, leading to the term “decision scaling”. MEC project and objectives were presented by the visiting delegation including needs for monitoring and reliable data and modeling, overview of Morocco’s water challenges and proposed solutions, and the national water strategy. USACE has been engaged to support collaborative planning in Souss Massa project in Morocco. Discussions covered risk informed decision-making, risk evaluation, analysis, decision support in surface waters and paleoaquifers. Also, transboundary water transfers and the refresh of water master plans in Morocco were explored as well as public-private initiatives underway for improving water supply and access.

There are opportunities for collaboration between Moroccan agencies and the USACE IWM, with enthusiasm from both sides, including: ICIWaRM software for integrated water resources management, used at a number of locations and international agencies and ready for implementation in Morocco; the G-WADI drought tool; extending the collaboration with HEC to use USACE modeling software including CWMS; and others.

4.2 US GEOLOGIC SURVEY (USGS), INTERNATIONAL WATER RESOURCES BRANCH, RESTON, VIRGINIA

Attending: Verne Schneider, Mike Foose, Bill Cunningham, Randy Hanson, Jo Leslie Einers, and others

The MEC and Moroccan delegation presented on the MEC objectives and overview of the project, the nature and problems with aquifers in Morocco and groundwater degradation as measured by a network of gauging stations, the impact of sea water intrusion, and priority initiatives including spring restoration, improvement of groundwater management and building of small stockwater resources.

The USGS presented an overview including the USGS's water mandate and high-level missions including ecosystems, climate change and water resources, flood inundation, National Water Quality Assessment program, the Ground Water Atlas of the U.S. The USGS makes available all of its water resources data to the public via the Internet at no charge. This policy has contributed substantially to improving surface and groundwater modeling and management, and could be considered by the Moroccan government.

Groundwater modeling at USGS is very relevant to the situation in Morocco. Discussion centered on groundwater sustainability, conjunctive use, and to adaptation to climate change including seawater intrusion. Other topics included MODFLOW and GMS modeling systems; water allocation optimization; western water law; use of remote sensing to acquire ground data on water distribution and on crop and native plant evapotranspiration; and, water quality and quantity degradation.



Figure 1: Meeting with USGS International Programs Office in Reston, VA.

4.3 US BUREAU OF RECLAMATION (USBR), INTERNATIONAL AFFAIRS, WASHINGTON, DC

Attending: Richard Ives, Kendra Russell

The USBR was established to develop the arid west for irrigation. (See Handout from USBR which covers this presentation). Under management are water resources of 40 trillion liters/year, 15,000 MW of installed capacity, serving 18 Bm³ and irrigating 1.2 B ha. Key issues in the western U.S. are a growing population and economy and the need for assessment of climate and impacts on federal projects.

4.4 NOAA/NATIONAL WEATHER SERVICE (NWS), SILVER SPRING, MARYLAND

Attending: Katie Labelle, Ed Clarke, Martin Steinson, Dan Beardsley

NWS dissemination of information including hazardous weather outlook, watch, advisory and warnings: NOAA weather radio (NWR), NOAA Weather Wire (NWW), Emergency managers weather information network (EMWIN), NOAAPort, tsunamis, space weather, winter weather, and

wildfire weather. Their top priorities are to improve weather, water and climate decision service; improve accuracy and lead times; communicate confidence in forecasts; and improve community preparedness and response.

One agency in U.S. predicts weather and 24 agencies work on prediction, operation and management of water. In Morocco, there is one agency for weather and one agency for water resources. The irrigation authorities do their own met prediction and monitoring. Satellite precipitation estimates and products covering Morocco. Weather Event Information, CHPS-FEWS. NWS has partnerships with other agencies including FEMA, USACE, USGS, states and others.

According to the national water law in Morocco, there are national requirements to produce flood maps and modeling and forecasting tools needed. Moroccan agencies are interested in collaborating with NWS and especially interested in flood guidance.

4.5 NOAA/NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION (NCEP), GREENBELT, MARYLAND

Attending: Lauren Morone, Mike Halpert, Bill Lapenta and others

NOAA has centers for environmental modeling, weather prediction, storm prediction, national hurricane, ocean prediction, climate prediction, space weather, aviation weather. The missions of centers are to produce reliable, timely accurate analyses, guidance, forecasts and warnings. Joint Agriculture Weather Facility with USDA and DOC. Transition of research into an operational environment. NCEP priority is on “global forecast system”. Global Data Assimilation System upgrade was implemented May 2012; CPC’s focus is on USA but it does some outlooks for Africa at 6-10 days and monitors global weather and climate conditions.

Discussion centered on NOAA’s interaction with users, data archiving, international work of NOAA, and potential for partnering with Morocco’s meteorological and water resources agencies to obtain precipitation forecasts and meteorological parameters, learn about drought monitoring and seasonal outlooks.

4.6 DEVELOPMENT ALTERNATIVES INC (DAI), BETHESDA, MARYLAND

Attending: Del McCluskey, Walter Weaver, Peter Reiss, Rene Clark, Bruce Spake and others

Areas of work in water resources management where DAI is active: strengthening resilience to climate change, water security vulnerability analysis, adaptation for resilient rural livelihoods, water source protection, and integrated river basin management. DAI is particularly interested in taking science down to farmer for their adaptation, crop selection, etc., improving water use efficiency, and expanding water and sanitation services with market based approaches for expanding access to the very poor.

Under USAID funded Further Advancing Blue Revolution Initiative, DAIS is developing a “water network” in the Middle East and including Morocco. There are centers of study being promoted including a climate change center in Indonesia, and Ag-Health-Water center in the Middle East. FABRI has funds for research that should involve efficiency and productivity, groundwater, non-conventional water source, and/or WASH and a proposal from ONEP and one other agency in Morocco have been submitted. Topics not well represented, for which they’re looking for proposals include: water and energy; groundwater; and, proposals addressing policy, collaborative planning, financial management, etc. An extensive presentation was delivered on the USAID-funded SERVIR

project and its current involvement with centers in Kenya, Nepal and other locations, and other water-related projects in the Philippines, the Mekong and Jordan River basins. Discussion on a range of topics included water supply and sanitation and cost recovery, remote sensing and data management and opportunities for Morocco agencies to be involved in USAID funded grants and programs.

4.7 NASA GODDARD SPACE FLIGHT CENTER (GSFC), GREENBELT, MARYLAND

Attending: Shaheed Habib, Sujay Kumar, Fritz Pollichelli, John 'Bodig', Ted Engmann; John Bolten and others

The Moroccan/MEC delegation provided an overview of water issues in Morocco, the national water strategy and related issues. They also presented an innovative use of satellite imagery (Landsat) in Morocco to estimate actual evapotranspiration and to model unregulated groundwater abstractions for irrigation; NASA has supported research, development and applications of these techniques for several years. NASA is funding 21 research and applications studies in water resources management and is working on a number of USAID-supported activities including the SERVIR project and the FEWS-NET program.

In NASA's Global Modeling and Assimilation Office, the Land Information System (LIS) is used to assimilate data, couple land-atmosphere models and other applications, and satellite systems such as GRACE, MODIS, RADARSAT, VIIRS, etc. These and other NASA systems are being used in a range of applications including large-scale estimates of terrestrial water storage, the National Geographic Locust Detection system, crop identification, flood and drought monitoring, etc.

The NASA-USAID-World Bank funded MENA Water Information System, in Morocco is addressing: evapotranspiration, Drought, flood detection and monitoring, crop and irrigation mapping, other. NASA is providing satellite data products; algorithms to generate data products; open source models: drought, evapotranspiration, flood detection, climate impact assessment, initial training on accessing and using data products and models. The Moroccan delegation were particularly interested to discuss scientific advances, and the possibilities to collaborate with NASA, in precipitation estimations, snow mapping and modeling, land degradation, stream and reservoir sedimentation, flood forecasting and monitoring, crop and water use modeling.

4.8 THE WORLD BANK, WASHINGTON, DC

Attending: Julia Bucknall

Discussion of the World Bank programs in Morocco and North Africa and vision for longer-term support and investment.

4.9 STANFORD UNIVERSITY, WOODS INSTITUTE FOR THE ENVIRONMENT, NATURAL CAPITAL PROJECT

Attending: Adrian Vogel, Guy Ziv

NatCap's mission is to develop and apply credible ecosystem service expertise, provide training and dissemination and enable policy transition. The ecosystems services approach includes alternative management to ecosystem structure. NatCap has developed InVEST models and linkages; the strength is not in the models' technical details but in iteration, building capacity, informing decisions,

engaging stakeholders in preserving the services and enabling the dialogue and decisions. NatCap is collaborating with Latin America Water Funds and investments in green infrastructure, to determine how to get the best return on investment. One practice is to pay landowners to change practices or in providing no-cost land improvements, fencing of riparian areas or changing agricultural practices. NatCap has developed and works with RIOS: Resource Investment Optimization System. NatCap believes: simple models are best for diverse decisions; iterative science-policy process matters; accessible tools and capacity building are critical; metrics should resonate; specialized tools help with mainstreaming analyses and with acceptance.

Discussions revolved around evaluating and support ecosystems services in Morocco; water services and real cost of water; Morocco's problems of reservoir sedimentation, fisheries degradation and stream ecology. NatCap can help to setup the process and dialogue, identify the drivers, and data for scenarios, etc. Discussions about models, scale and appropriateness for the models, and about crop yield models using a proportion of Eta/ETp for multiyear yield analysis. Could a Water Fund work in Morocco, and how long would it take to setup and operate? The questions revolve around linkage of economics with the biophysical, and the question on environmental degradation and its complexity and the possibility for Moroccan agencies working with NatCap for analysis and demonstration.

4.10 GOOGLE, MOUNTAIN VIEW CALIFORNIA

Attending: Sean Maday, Kurt Schwehr, Peter Birch

Google's focal points and data and mobile. Google has a broad mandate: organize the world's information geographically and make it universally accessible. Google Earth has been downloaded more than 1B times. Presentations centered on GIS data and services over the internet including Google Maps Engine, Google Earth, and crises response. Google Earth Engine is a service platform that could be useful in Morocco, and any location on earth, for monitoring and analyzing earth resources, modeling water and agriculture and making the results available instantly and universally via Google's cloud and computing services.

4.11 US ARMY CORPS OF ENGINEERS - HYDROLOGIC ENGINEERING CENTER (HEC), DAVIS CALIFORNIA

Attending: Jeff Harris, Matthew McPherson, Chan Modini, Bill Charley

HEC provided an overview of their software and the 'virtuous circle' supporting systems in hydrologic statistics, HEC-SSP; HMS including hydrologic routing and snowmelt modeling with energy balance approach in the new version; reservoir simulations with the rule-based ResSim; Flood Damage Analysis & Flood Impact Assessments; Ecosystems Functions Model; and, Watershed Analysis including systems for reservoir and frequency analysis. Also, discussed the GeoHMS requiring DEM, network and radar rainfall grids from NWS, and the River Analysis System (RAS) which can be used for real time forecasting. Countries that USACE/HEC has worked recently include: Kenya, Ethiopia, Guyana, Korea, Iraq, Afghanistan, Italy, Paraguay, Uzbekistan, Tajikistan and Mongolia.

The Moroccan ABH delegation have considerable experience with the HEC models and are particularly interested in modeling reservoir operations, water management, impact on the ecosystems, flood and sedimentation analysis. The HEC tools do not allow modeling of conjunctive use and/or interactions of ground and surface water; however, there is a project underway to couple the MODFLOW with the River Analysis System. Through the MEC project, the ABHs will be deploying the non-Core version (RTS) of the Core Water Management System (CWMS) for streamflow and flood analysis. The HEC is aware that this will result in the first CWMS system

operational deployment outside the U.S. for an important application and offered their assistance to ensure the project success and their interest in working with future projects in Morocco and the region.

4.12 CALIFORNIA DEPARTMENT OF WATER RESOURCES (DWR), JOINT OPERATIONS OFFICE, SACRAMENTO

Attending: Tracy Petite, Liz Kiteck, Maurice Roos, Sudhanker Talanki, Sean de Guzman

The Central Valley Project (CVP) provides much of the irrigation water in the state generates 5.5B kilowatts/year and is the largest water development project in the USA. There are many environmental requirements particularly with water quality which is measure via automated sensors and reported every 15 minutes. The water forecast was issues on April 1 with a grim forecast of 70% for municipal and industrial water and 20% for agriculture. Federal contractors pay about \$20 to \$30/af for water but on the private market it can be ten times that price.

The State Water Project (SWP) supplies water for 25 million residents, irrigation water for one million acres, and is the largest single power consumer in the state. Models used include the (Sacramento River) Delta Model; SWP Allocation Model; CALSIM, as a planning tool for long-term analysis and simulation of impacts of policy; and, DSM2 for water quality modeling. The jointly administered State-Federal Flood Operations Center works with the US National Weather Service, located in the same building and supported by Riverside under contract through the national contract in Washington, DC, and produce reservoir inflows, river flows and water levels throughout the state.

Discussions reflected the Moroccans' interest in predicting impacts of climate change including sea level rise, snow and rainfall amount and timing, water temperature and water quality, and alternative adaptation measures.

4.13 CALIFORNIA STATE WATER RESOURCE BOARD, SACRAMENTO

Attending: Gita Kapathi, Rich Breur, John Borkovich, Jim Kassel and others

The Board of Water Control is a state regulatory agency with appointed members charged with ensuring waters are used beneficially and that those rights are protected. They monitor and enforce state laws and policy through nine regional offices. The Surface Water Ambient Monitoring Program (SWAMP) provides managers and the public with information for management decisions via web portals and other dissemination tools. In 2006, the State passed a law to limit GHG Emissions. The same bill setup a Climate Action Team under Cal-EPA (the mother agency). WET CAT is charged with water and energy efficiency. California has a very energy intensive water network. The plan first written in 2008 shows 5 areas for the water sector to achieve efficiency: i) less water use; ii) less use for cleaning; iii) recycle/reuse of water; iv) water energy efficiency of pumps and pipes and pressure reduction etc and reuse of storm water, installing solar and wind on water facilities. About 19% of energy used in the state is used for water for conveyance, pumping, etc., especially groundwater pumping during summer months. Groundwater makes up over one-third of the water used in the state, and there are a number of programs for monitoring and management including Groundwater Ambient Monitoring and Assessment, GAMA. The types of water rights in the state are Pueblo, Riparian, Federal Reserved, Appropriative (pre and post 1914). Discussion among the delegation and the state officials addressed climate change mitigation and adaptation measures,

California laws as compared to federal law and interaction with federal agencies such as EPA, improving efficiencies in water pumping and conveyance to reduce energy consumption, collaboration with universities for innovation and science for improved water management.

4.14 BYRON BETHANY IRRIGATION DISTRICT, CENTRAL VALLEY, CALIFORNIA

Attending: Kelly Geyer

BBID is about 50,000 acres irrigated land. Some water rights are pre-1914 and they have plenty of water. The post-1914 rights are highly constrained this year and some will only be receiving 0.65 ac/feet/ac. Discussion about the formation of the water district, history, about the water rights and the management of the district, the relationship of water district to farmers to state and USBR.



Figure 2: Discussions with water managers near Sacramento

4.15 GALLO FAMILY VINEYARDS

Attending: Martin Mendez-Costabel, Andy Morgan, Ernie Dosio

All vineyards in California require irrigation. Although the water used is relatively low-cost, Gallo is working to improve conserve water and to improve the quality of its products through more controlled and precise irrigation applications. Their water efficiency research and development group uses remote sensing, GIS and irrigation technologies. Satellite imagery is used along with ground-based meteorological data and Internet-enabled mobile devices for precise water and fertilizer applications and for yield monitoring, computing indices and evapotranspiration maps, measuring leaf canopy, sap flow and other measures. IBM is implementing a micro-irrigation system that provides irrigation, nutrients and other inputs as demanded by each individual vine.



Figure 3: Field water management site in Central Valley, California.

4.16 NASA-AMES RESEARCH CENTER, EARTH SCIENCE DIVISION

Attending: Ed Sheffner, Forrest Melton, Vince Ambrosia, Matt Fladeland, Jennifer Duggan, Bill Thigpen, Dr. Worden, Mike Flynn and others

California and Morocco have some areas of commonality including size, climate and water resources. California agriculture annual sales are over \$40B from 81,000 farms. NASA is supporting and conducting research and development on the hydrologic cycle and terrestrial-atmosphere processes using satellite and airborne remotes sensing. Some of the satellite missions include Jason, QuickSCAT, Landsat, TRMM, Aqua, GRACE, ICESat, and CALIPSO, data processing algorithms and collaborative computing platforms for Earth science data analysis and modeling. NASA also is pioneering the use unmanned aerial vehicles (UAVs) for estimating irrigation water consumptive use, monitoring soil moisture and estimating crop yields. NASA's applied sciences programs are accelerating applications, developing training modules, and conducted analysis globally for soil moisture, water and energy cycles. The satellite irrigation management support (SIMS) is a successful example where users can click on a certain point and retrieve a range of information and/or analysis results including California Information Management Information System (CIMIS), evapotranspiration maps, snow water equivalent and using the NASA Earth Exchange (NEX) for big data processes and storage.

5. CONCLUSIONS

The Moroccan Study Tour delegation was exposed to a range of highly relevant water resources issues facing the U.S. Meetings, presentations, dialogue and exchange were conducted with key federal agencies responsible for water resources management, policy and governance, state operations and regulatory agencies, developers of models and data management tools, private sector innovators in science and technology, and field water managers. This stimulated discussions about the very similar issues in Morocco and, particularly, how data management, modeling tools, management approaches, and policies could be improved. Also, there was much anticipation for future collaboration between our Moroccan delegates and the U.S. agencies.

The US-based hosts for the study tour were highly committed, well prepared and effective collaborators. The pre-planning, logistics, approvals and processing were conducted efficiently and effectively by USAID/Morocco, MEC project staffs, DAI and Riverside staffs.

A wealth of positive feedback has been expressed by the participants since completion of the study tour in mid-April. The only known concern was from some members who thought the agenda was ambitious, but even those individuals have since expressed their satisfaction with the comprehensive approach and range of topics addressed. From a programming perspective, the study tour likely would have had more positive impact on MEC success had it been conducted earlier in the life of the project.

The Moroccan officials are grateful for their experience and for the time and energy devoted to this rich and rewarding study tour, as expressed by one of the senior members:

I am writing you this message to show you my thanks for everything you have done for the success of the study tour to the USA. This trip was very beneficial and has personally helped me discover many things and especially some innovations (underway in USA)....